Chapter 6: The Design of Concrete Coastal Fortifications

Many authors have described the fortifications that once protected San Francisco and have commented on their richness as historic properties. The comments are in part a response to the quantity and variety of defensive works that have survived to the present. From the landmark qualities of Fort Point, through the simple shapes of the 1870s, to the manifold types of the 1890s, and concluding with the subtle forms of the 1940s, it is a collection of great number. As collections go, it is also disquieting since there is nothing here to indicate the evolutionary nature of fortification design and construction. The structures of each period appear unique unto themselves, claiming no antecedents and leaving no descendants. They create the impression that their designers drew only from within themselves for inspiration, if inspiration was called upon at all, and that their later fellows tore up existing notes and drawings to begin wholly anew. The names of the builders are lost or unrecognized, and to that anonymity we have added our own doubts about the historical merits of these structures, aided by the tendency to sniff with great suspicion around the animal called military architecture.

It is not a new attitude. More than fifty years ago, M. Waterhouse, the Honorary Secretary of the Royal British Institute of British Architects, drew a blank when struggling with language that would define military construction. "It cannot be called Architecture," he declared, "either as we knew it—or as we know it ought to be. I don't know what it really can be called. I am tempted to define it as a combination of Organization and Improvisation."[1]

While organization and improvisation are well-traveled approaches to the construction of expedient defenses, the fortifications remaining throughout the Golden Gate National Recreation Area are the products of skillful engineering, deliberate construction, and money. The defenses have their designers, and the designers, after a fashion, have their inspirations. We need not look for a Palladio or a Wright, and we should not try to identify the equivalent in military architecture of a Villa Capra or Fallingwater. As stewards of historic property, however, we should know who designed what we are now charged with caring for, and we should have some sense of why they made the decisions they did.

Previous research, notably the work accomplished beginning in the late 1960s by historians of the National Park Service as well as other scholars, identified some of the principals and the chronology of their work. As a result, we know some about the construction of the 1870s, a great deal more about what took place in the Endicott and Taft years, but almost nothing about the designs of the 1940s. There are several reasons for the gap in the most recent period, however the lack of specific knowledge has little impact on what we know about the building of fortifications out of concrete. The use of concrete for defensive purposes was explored thoroughly in the years before World War I, and it is that period of innovation that is the most instructive. However, to fully comprehend the marks that fortifications have made on the landscape, our vision must extend beyond the material of construction itself. We must look at American military experience, the impressions made or not made by other nations on the American military, and a native engineering contribution to a distinctly American form of coast defense (Plate 43).

The utilitarian and rhythmic emplacement-and-magazine plan of the 1870s batteries at Fort Scott owes its heritage to the Civil War, and there is little to separate them from similar fortifications of that conflict. Yet Cavallo Battery is a distinguished design and it has no surviving counterparts. Its seaward face is well understood, but its general trace and rear parapet suggest some similarities with French fortifications erected in the Franco-Prussian War, especially in regard to the positions for land defense armament at the extremities of the plan. American officers regularly toured the battlefields, arsenals, and fortifications of European nations, and did so even until the late 1930s, and what others were doing became part of the base of ideas that contributed to the defenses[2] (Plate 44).

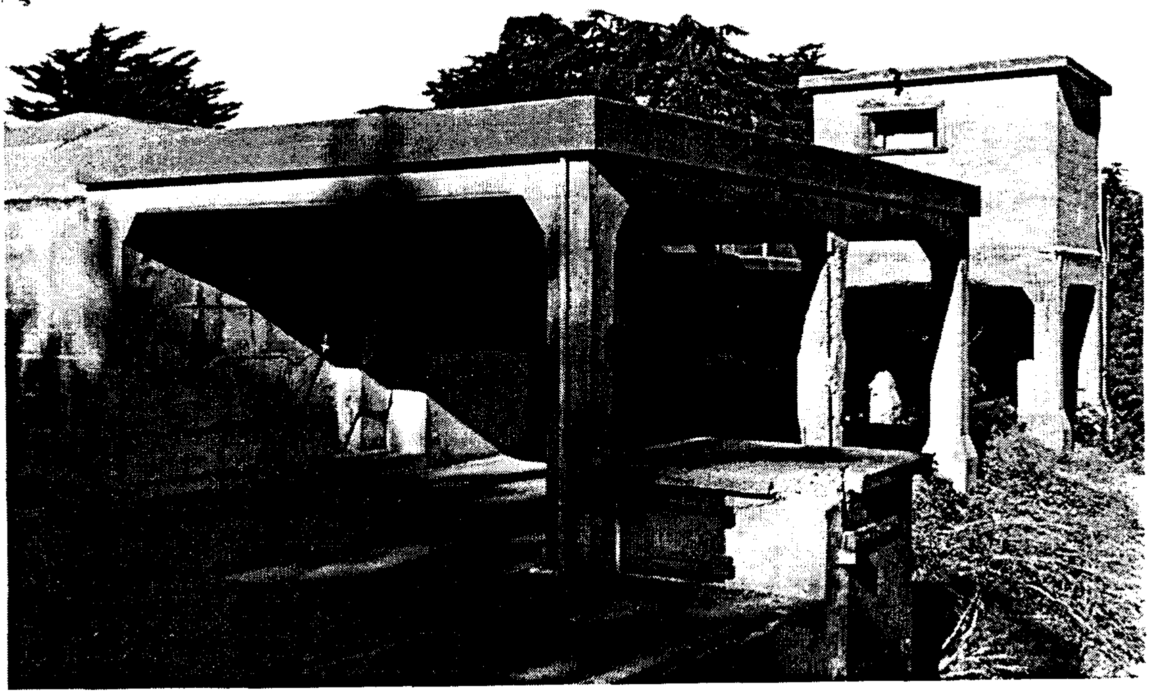

Plate 43. Even after the structures of the Endicott and Taft periods were completed, there was a pattern of improvements that also incorporated advances in concrete construction. The telautograph booth, ammunition hoist and splinterproof, and battery commander's station, shown here, were built between 1904 and 1912. These additions at Battery Marcus Miller were among the first attempts to use reinforced concrete in the fortifications.

Plate 44. The design of Cavallo Battery called for the work to be accomplished in earth, and rendered in regular outlines. Those crisp outlines have been obscured by a century of plant growth.

At the same time that Colonel Mendell was reconfiguring the ground at Point Cavallo to look more like a fortification, builders in Europe and especially England, were investing great sums to mount large muzzle-loading cannon in granite fortresses sometimes plated with iron. It was an astounding investment for the time, particularly since it appeared to be an endorsement of a type of ordnance that was born in the age of sailing ships, yet for England there was little choice. Both France and Italy had launched impressive armored vessels, and an immediate response was essential to defend both home and Mediterranean ports. These same kinds of vessels could pose an equally decisive impact on American coastal cities, although the possibility was slight. Both the Atlantic and Pacific Oceans were barriers to many early iron warships, and the insurance they provided allowed American engineers years of grace in which their counterparts of other nations could not share.

The coming of modern fortifications was slow in the United States. There was little need for speed, and in any case, Congress was not likely to provide any funding for a new defensive network with the Civil War so recently passed. There was movement, however. In January, 1873, a board of officers met to decide what sort of weaponry would be best suited for defense against the new naval vessels, and they came to a decision that would govern the appearance of defended harbors for years to come. They opted for guns mounted on depressing or disappearing carriages. They gave special encouragement to the proposals of Captain A. R. Buffington, who some twenty years later, would produce the prototype of all disappearing carriages to be placed in U.S. service.[3]

The selection of a disappearing carriage, either Buffington's or any other competitor for the design, meant that the batteries mounting it would have to be big—at least as tall as the machinery that would move the cannon above the parapet—and would have to be scaled in two stories. The first or lower story would contain the magazines for the projectiles and powder, and the upper story would provide a platform for the gun. Those requirements meant that earth was gone as a basic building material. Stone was an alternative, but it could only be worked by skilled craftsmen, while another material would be just as good and less expensive as well. It was concrete, and the adaptability of the material propelled it into the forefront of choice (Plate 45).

Plate 45. Although the batteries of the 1870s were built of earth and brick, concrete played an important role as well. Here a groin formed by the intersection of vaults in East Battery is made of concrete, displacing more expensive brickwork.

The engineers had considered other alternatives, most notably the iron-sheathed walls of masonry fortifications being erected in Europe, but they were costly. In any case, that technology would be difficult to adapt to the type of armament suggested by the Endicott Board in its report of 1886. The engineers were confident that concrete would meet all their needs. There was little difficulty adapting the conventional methods of concrete construction to the construction of fortifications, and not much was different in the methods of erecting the plant or placing the material.[4]

The specification for concrete was general, and to get it right a great deal depended on the abilities of individual engineers to translate the broad instructions into more detailed measures to be taken by supervisors and contractors. A sense of just how general the approach was can be gained by this excerpt from the notes accompanying a new standard design for a battery of 6-inch guns:

> The proportion of cement, sand and broken stone will depend largely on the quality of the materials. One to three is a common ratio for cement to sand, but the amount of sand can be increased if the results of briquette testing so justify. The run of the crusher should be taken for the stone, and 1-1/2 inches should be the superior limit of the size. Enough water should be used to insure a concrete as wet as can be conveniently handled, and the mortar should be fairly flowing so as to settle into and thoroughly fill all voids in the stone after tamping. The proportion of mortar to stone...should be so adjusted that after tamping, the upper layer of stones should project at least half their thickness above the main mass.[5]

There were, however, a few new ideas that bear mentioning, and they had to do with either increasing resistance or increasing cohesiveness of concrete. In the Endicott and Taft structures, earth was still an important material, and counted upon to slow the penetration of projectiles striking the defenses. As further protection, the engineers dumped large boulders called deflectors into the concrete mass, the idea being that these huge stones would cause the projectiles to bounce away from critical areas. Chunks of the demolished West Battery were added to Battery Godfrey during its construction for apparently the same purpose. There was also concern that the long bolts holding the carriage to the emplacement might rack and twist when the gun was fired, an action that would weaken the concrete and loosen the connection with the carriage. As an aid in resisting fracture, the builders of some early emplacements in San Francisco created a framework of iron interlaced with surplus cables from the street railway, and the concrete was then tamped into the framework. Both of these practices fell away as experience accumulated.[6]

Experience in modern fortification construction was a rare commodity when work initiated at the San Francisco defenses. The earliest construction had begun in 1890 on the East Coast, and engineers who had overseen these efforts then went to other projects already underway or about to start. They took with them what they had learned by doing, and a practice of exchanging plans and information about fortification construction with their peers. It was at first an informal process, and then made more uniform by guidance issued regularly by the Chief of Engineers, although the official guidance did not halt the discussion among what was a very small group of individuals. Prior to 1900, engineers had an open invitation to adapt basic requirements to meet their particular needs. Those that did created batteries notable for their innovations, but a national defense system based on unique structures meant that estimating construction costs would be impossible. As a result, the Chief of Engineers in 1900 directed that unless otherwise required by some remarkable local conditions, engineers designing the fortifications remaining would do so by following the standard designs issued from his office.[7]

All of these aspects of design, experience, and standardization reveal themselves in many ways during the 1890s and early 1900s in the San Francisco defenses. What emerges from that perspective is an interpretation of the fortifications that shows them to be distinctive rather than an indication of what was done elsewhere. The collection of gun batteries at Forts Scott, Baker, and Barry also demonstrates that the unusual dominates the expected, and this circumstance figures more into the significance of the historic resources than does their large number (Plate 46).

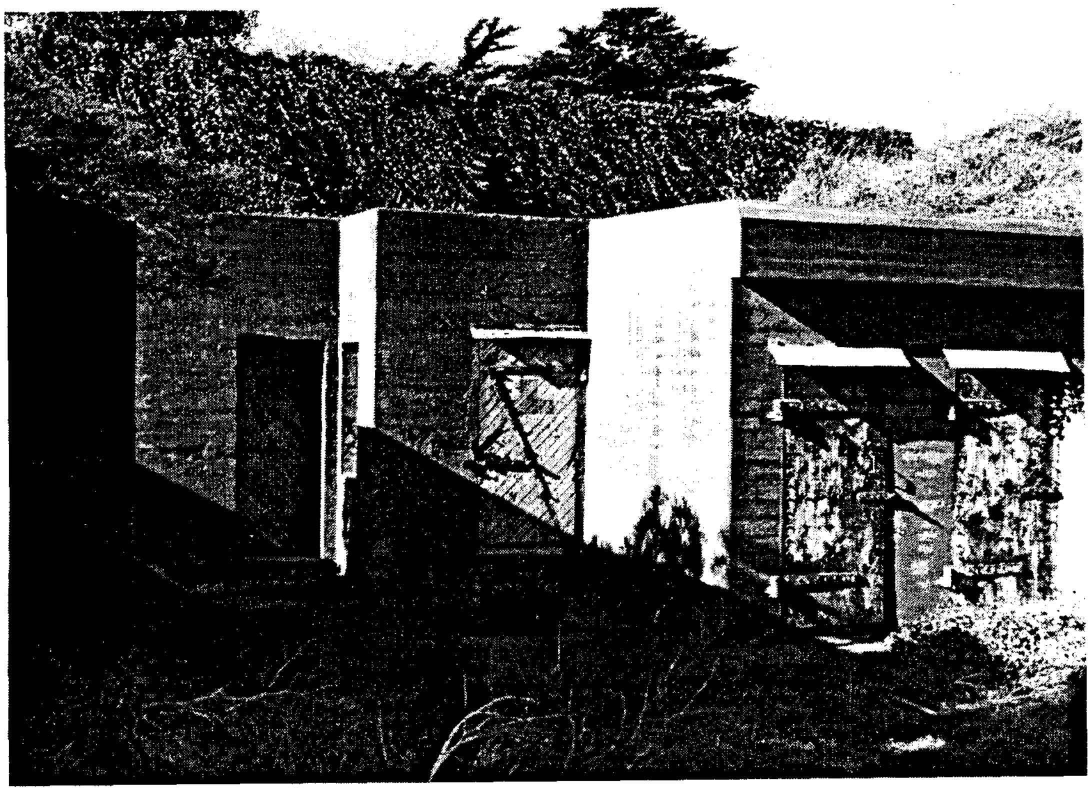

Plate 46. The designs for the earliest batteries did not anticipate the need for latrines, power plants, plotting rooms, and storage spaces. As a result, later building tacked on these components to fortifications completed only a few years before. These additions at Battery Godfrey are an example of the practice; they also portray the preference for steel doors in later construction.

The defenses of San Francisco were a laboratory in which young engineering officers could find practical experience in how to build a modern concrete fortification. It was an occupation of many parts, from requisitioning materials to measuring the monthly progress of the work. It was a practicum much endorsed by Colonel Mendell. "It is considered a fortunate condition," he said, "for a young Officer to get his first introduction to the profession under such circumstances; and the officers who have gone through this practical school at Fort Point, have, so far, justified all reasonable expectations. They have learned from the system which they found in operation, or which they aided to establish, sound means of construction in masonry & earth; the management of men; a reasonable task for a laborer, and the business habits essential for success."[8]

It was not one of the young Turks hailed by Mendell that left the most indelible stamp on the San Francisco defenses, but a senior engineer much like himself. Mendell retired in 1895, moving on to a position with the city's Board of Public Works until his death in 1902. His position as district engineer was filled by Charles Suter, about ten years younger than Mendell, but like Mendell a veteran of much action during the Civil War. Suter had a creative mind, and it was his opinion that the weakest part of fortification design lay in the way that ammunition was moved or lifted from the magazines to the level of the loading platform. There was too much movement and too much reliance on machinery to do the job faultlessly, and his concern was that those faults would only reveal themselves in action when it would be too late to make any changes.[9]

"The abolition of lift is of so much importance as to justify almost anything," he once wrote in support of a design that had been based on one of his batteries in San Francisco. Perhaps the most arresting quality of the batteries for heavy guns built to protect the Golden Gate is the number of them that were constructed without ammunition lifts or any provision for them, and Suter appears to have been associated with most if not all of these designs. Batteries Slaughter, Kirby, Duncan, and two emplacements of three at Battery Lancaster had no lifts at all, and this at a time when the most ordinary form of an American coastal battery for heavy guns was its distinctive two-story appearance and ammunition hoist. Suter's design for Battery Saffold incorporated traditional lifts, but added a new element. As convention dictated, there was a road or battery parade to the rear, and supplementing it was an unconventional paved road to the loading platform. That additional road meant that in case the lifts failed, ammunition trucks could still exit the rear of the battery and reach the guns, courtesy of Suter's thinking.[10]

Suter left San Francisco in 1898, and he continued his work while he was assigned to fortification construction in other harbors. In the end he was successful, and an example of Suter's final design is Battery Chamberlin, which was reproduced in great number in all the defended harbors. (See Plate 28, chapter 5.)

Also unusual is the number of designs that ignored the guideline identified as the horizontal crest. To ensure the invisibility of the defenses and to make the most of the qualities of the disappearing carriage that was the backbone of coast defense, no part of the defenses were to be visible from the sea. The battery location would appear as a flat line, or a horizontal crest. Yet Battery Slaughter did not have a horizontal crest, and neither did Kirby, Duncan, Lancaster, or Marcus Miller. Stranger still, two of those batteries—Lancaster and Marcus Miller—did not mount their guns all at the same elevation.

One oddity of many of the San Francisco defenses is an unusually deep traverse, that is, the side walls of the emplacement are carried back further than typical. That feature was shared by Duncan, Lancaster, Rathbone, Slaughter, and to some extent, Cranston. Less odd, but certainly notable are the number of single gun emplacements, usually frowned upon because of their high cost: Batteries Chester, Godfrey, and Marcus Miller all contain third emplacements that functioned as single gun emplacements, and Batteries Burnham, Drew, and Wallace were built as single-gun batteries.

Of all the major caliber gun batteries in San Francisco of this period only Battery Mendell and emplacements one and two of Battery Chester were conventional. The plan of Battery Spencer was so contorted that only two of the three guns were useful (the battery commander's station did not even have a field of view of the water area covered by the third gun); Battery Saffold contained improbable features that allowed its guns to fire well to the rear into San Francisco Bay; and Battery Dynamite was in every respect the two-headed calf of coast defense.

Many of these unusual aspects were adaptations to the terrain just as they were an important indication of the skill and invention of the engineers as they tried to perfect the defense of one of the nation's most important harbors. Still, given that such specialization does not seem to have taken place to an equal degree elsewhere, there may be merit to the thought that the defenses of the 1890s were over-built. It gives some truth to the comments of a foreign observer that "the preposterous proposals . . . for the defense of a comparatively unassailable port such as San Francisco, have created extravagant standards attainable only by a people disposing of superabundant funds, and, if attained, adding nothing to national security."[11]

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[1] As quoted in Keith Mallory and Arvid Ottar, *The Architecture of War* (New York: Pantheon Books, 1973), 9.

[2] Quentin Hughes, *Military Architecture* (New York: St. Martin's Press, 1974), 225.

[3] *Annual Report of the Chief of Ordnance, Ordnance Memoranda No. 16*, Serial 1599, 43rd Congress, 1st Session, 452.

[4] Colonel Eben Eveleth Winslow, *Notes on Seacoast Fortification Construction,* Occasional Papers, Engineer School, United States Army, No. 61 (Washington, D.C.: Government Printing Office, 1920), 52 and 54.
[5] Board of Engineers to the Chief of Engineers, 14 October 1902, in *Mimeograph No. 40, 2nd supplement*, 6. An example of concrete meeting the specification that the aggregate should protrude half its thickness above the main mass can be found at Battery Godfrey, emplacement three. At the extremity of the emplacement, the finish layer has broken off, presenting a clear view of the mass layer beneath it.
[6] Erwin N. Thompson, *Historic Resource Study Seacoast Fortifications San Francisco Harbor Golden Gate National Recreation Area California* (Denver: U.S. Department of the Interior, National Park Service, 1979),144; *Mimeograph No. 40, 2nd supplement*, 5.
[7] John Millis to Alexander MacKenzie, 5 January 1904, Defenses of Puget Sound, Records of the Office of the Chief of Engineers, RG 77, National Archives and Record Center, Seattle.
[8] G. H. Mendell to the Chief of Engineers, 4 October 1895, later published as *Mimeograph No. 1.*
[9] *Register of Graduates and Former Cadets of the United States Military Academy* (West Point, N.Y.: West Point Alumni Foundation, Inc., 1970), s.v. Mendell, George Henry, and Suter, Charles Russell.
[10] Suter's quote and other information about his design contributions is more fully contained in David M. Hansen, "With Every Problem Solved: The Development of Mechnical Ammunition Hoists in America's Coastal Fortifications," *Coast Defense Study Group Journal* (November 1998).
[11] Sir George Sydenham Clarke, *Fortification; Its Past Achievements, Recent Developments, and Future Progress* (Liphook, GB: Beaufort Publishing Ltd.: n.d.), reprint of 1907 edition, 169.

PART III

TREATMENTS

Chapter 7: Elements of Deterioration

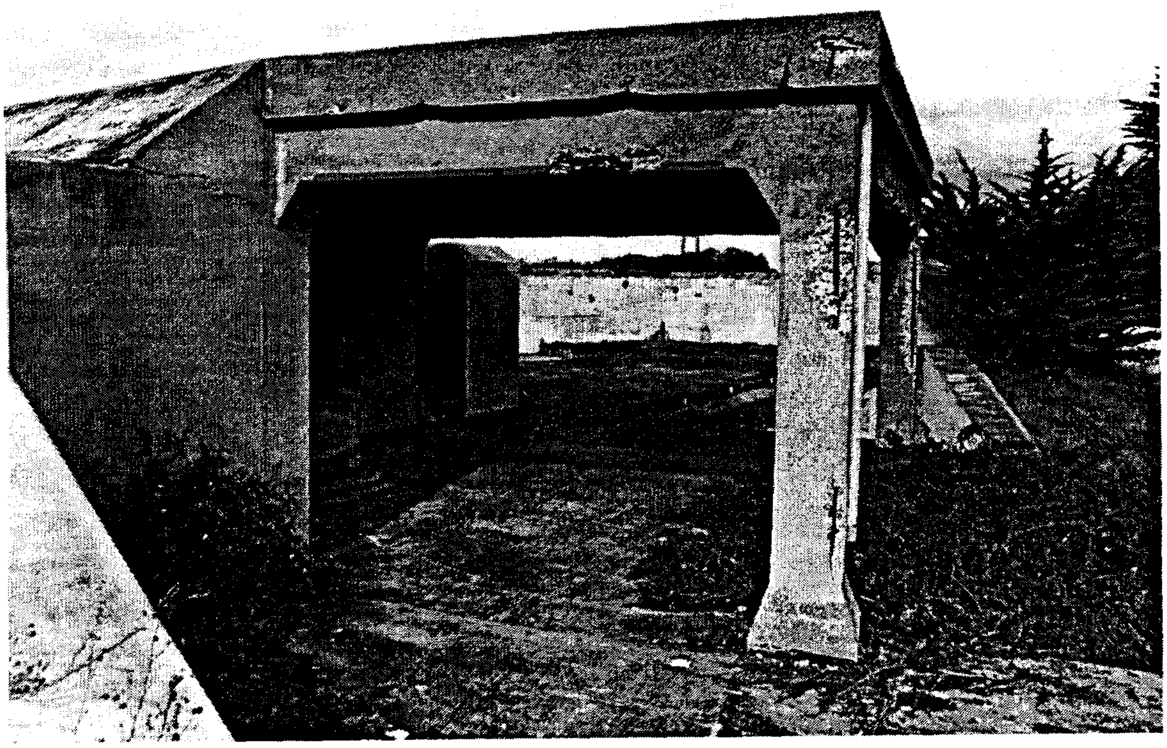

Plate 47. Concrete spalling is evident in the splinterproof at Battery Crosby, Fort Winfield Scott, constructed 1899-1900. Splinterproof added between 1904 and 1912.

Just as the fortifications reflect the evolution of fixed weapons from smooth-bore cannon to large caliber rifled guns and missiles, the fortifications show an evolution of construction methods and materials that parallel technological innovations that occurred from the Civil War to the Cold War (Plate 47). Construction methods and logistics such as roads for access, materials storage and handling, and water and power for construction permanently altered the immediate building sites and the surrounding landscape. Beyond the design influences of terrain, armament, and military doctrine, the fortifications represented mastery of traditional brick masonry construction, experimentation with plain and reinforced concrete construction during its formative period, and ultimately proficiency in advanced reinforced concrete construction.

The U.S. Army Corps of Engineers was well-informed about advances in the technology of limes, mortars, and cements both in the United States and in Europe in the latter half of the nineteenth century. Indeed, the military's interest paralleled early experimentation in the development of Portland cement in England and Europe and the Rosendale cements in the United States. Due to the limitations in the quality, consistency, and quantity of naturally occurring cements, military engineers sustained a keen interest in the manufacture of kilns, rock crushers, testing methods, structural calculations, and in new uses for cementitious materials. The value of cement in military construction was obvious. When combined with sand, gravel, crushed stone, and water in proper